Comparison of 2 approaches for freeze/thaw detection from ASCAT data.

Christoph Paulik, Simon Zwieback, Vahid Naeimi, Wolfgang Wagner and Richard Kidd

Vienna University of Technology
Institute of Photogrammetry and Remote Sensing
Güßhausstraße 27-29, 1040 Vienna

cpa@ipf.tuwien.ac.at
www.ipf.tuwien.ac.at/radar
Freeze Thaw State

- Hydrological cycle
- Plant growth season
- Global carbon and methane budgets
- Flagging of soil moisture measurements
Backscatter behaviour

The diagram shows the backscatter behaviour over a period from January to December. The x-axis represents the months, and the y-axis shows the temperature depth in grams per square centimeter. The data is represented with two lines, one for each month, indicating the temperature depth changes throughout the year.
Decision Tree method

HMM method

\[
\begin{pmatrix}
\exp(aT) & \exp(\alpha T) & \exp(aT) \\
\exp(bT) & \exp(\beta T) & \exp(bT) \\
\exp(cT^2 + dT) & \exp(\gamma T^2 + \delta T) & \exp(cT^2 + dT)
\end{pmatrix}
\]

ERA-Interim Temperature $T$
Validation strategy

Compare Surface State Flag (SSF) and Temperature Data

<table>
<thead>
<tr>
<th>Flag Value</th>
<th>255</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surface State</strong></td>
<td>Not valid</td>
<td>unknown</td>
<td>unfrozen</td>
<td>frozen</td>
<td>Temporary water surface/melting condition</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class</th>
<th>Agreement</th>
<th>Disagreement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Condition</strong></td>
<td>Temperature &lt; 0°C and SSF 2</td>
<td>Temperature &lt; 0°C and SSF 1/3</td>
</tr>
<tr>
<td></td>
<td>Temperature &gt; 0°C and SSF 1/3</td>
<td>Temperature &gt; 0°C and SSF 2</td>
</tr>
</tbody>
</table>

maximum Temperature

minimum Temperature
Agreement with temperature data

**Meteo Data (ds512)**

<table>
<thead>
<tr>
<th>Season</th>
<th>SSF</th>
<th>SSF + climatological flags</th>
<th>HMM FT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>77,87</td>
<td>84,12</td>
<td>87,45</td>
</tr>
<tr>
<td>TZ1</td>
<td>71,67</td>
<td>81,57</td>
<td>85,77</td>
</tr>
<tr>
<td>Summer</td>
<td>92,32</td>
<td>98,62</td>
<td>98,64</td>
</tr>
<tr>
<td>TZ2</td>
<td>73,41</td>
<td>86,71</td>
<td>87,58</td>
</tr>
<tr>
<td>Total</td>
<td>81,93</td>
<td>90,26</td>
<td>92,09</td>
</tr>
</tbody>
</table>

**GLDAS soil temperature**

<table>
<thead>
<tr>
<th>Season</th>
<th>SSF</th>
<th>SSF + climatological flags</th>
<th>HMM FT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>89,52</td>
<td>93,77</td>
<td>93,50</td>
</tr>
<tr>
<td>TZ1</td>
<td>68,72</td>
<td>75,66</td>
<td>82,70</td>
</tr>
<tr>
<td>Summer</td>
<td>91,56</td>
<td>97,35</td>
<td>97,88</td>
</tr>
<tr>
<td>TZ2</td>
<td>74,16</td>
<td>86,21</td>
<td>86,41</td>
</tr>
<tr>
<td>Total</td>
<td>84,27</td>
<td>90,75</td>
<td>91,94</td>
</tr>
</tbody>
</table>
Influence on soil moisture retrieval

- Data from ISMN
  - 17 Networks
  - 500 Stations

http://www.ipf.tuwien.ac.at/insitu/
Influence on soil moisture retrieval

The diagram illustrates the impact of data at different soil depths on moisture retrieval. The key points are:

- Data from 0 cm and 5 cm depths are shown.
- There is a symbol indicating 'Bad Data' between the two depths.
- A graph on the right shows variations over time (t) with moisture content (sm) and cumulative distribution function (CDF).

The diagram suggests that data from 0 cm and 5 cm depths should be considered separately due to the 'Bad Data' issue.
Surface State Flag + climatology vs. No FT
Conclusions

- Validation of Freeze/Thaw products is problematic
- Operational use in soil moisture flagging demands global coverage
- Both algorithms have issues over certain areas
- HMM FT method provides stable results
  - Computational expensive
  - Needs temperature timeseries (NRT)
  - Parametrization needs fine tuning
  - Trial with soil temperature instead of air temperature
- SSF+climatological flags
  - No fitting of logistic function leads to inconsistent flagging
  - Investigate problems in spring
Thank you